U.S. DEPARTMENT OF COMMERCE
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PB-256 632

Lake Maxinkuckee Marshall County, Indiana

Pacific NW Environmental Res. Lab.

Prepared For
National Environmental Res. Ctr.

April 1976

243116

PB 256 632

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

P.O. 699-440

REPORT
ON
LAKE MAXINKUCKEE
MARSHALL COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 335

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
APRIL, 1976

TECHNICAL REPORT DATA *(Please read Instructions on the reverse before completing)*		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Lake Maxinkuckee, Marshall County, Indiana		5. REPORT DATE Prepared April, 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 335
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		39 pp.
	20. SECURITY CLASS *(This page)*	22. PRICE $4.00/2.25

EPA Form 2220-1 (9-73)

PRICES SUBJECT TO CHANGE

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

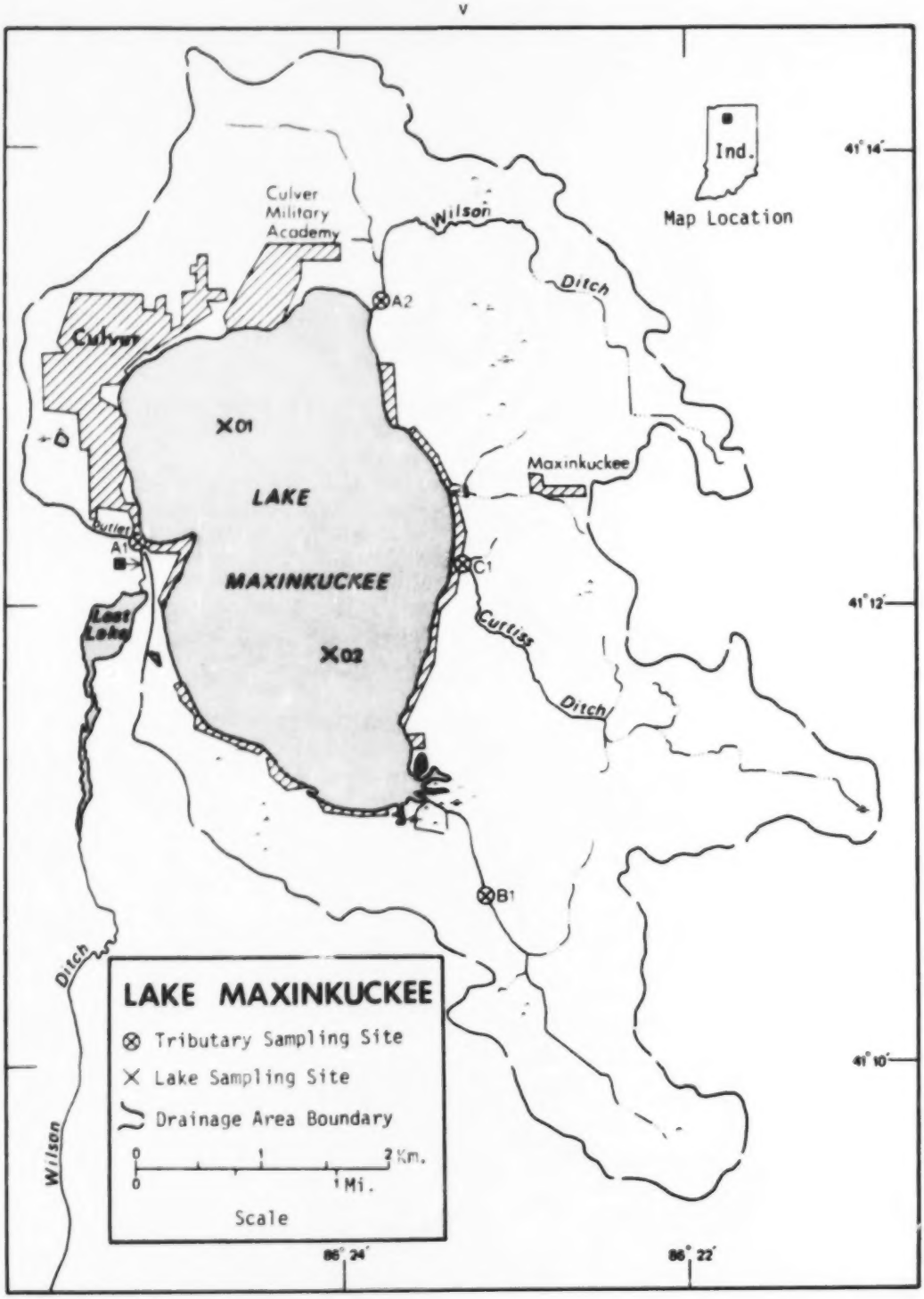
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


Ind.
Map Location
41° 14'
Culver Military Academy
Wilson
Ditch
A2
Culver
X01
D
LAKE
MAXINKUCKEE
X02
Maxinkuckee
Outlet
A1
Lost Lake
C1
Curtiss
Ditch
41° 12'
B1
Ditch
LAKE MAXINKUCKEE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1 2 Km.
0 1 Mi.
Scale
Wilson
41° 10'
86° 24'
86° 22'

LAKE MAXINKUCKEE

STORET NO. 1843

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Maxinkuckee is mesotrophic. It ranked fifth in overall trophic quality when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Six of the lakes had less median total phosphorus, none of the others had less but two had the same median dissolved phosphorus, five had less median inorganic nitrogen, four had less mean chlorophyll a, and four had greater mean Secchi disc transparency. Depletion of hypolimnetic dissolved oxygen occurred at station 1 in August.

Survey limnologists reported submerged macrophytes at station 2 in August and October and sparse growths at station 1 in October.

B. Rate-Limiting Nutrient:

The algal assay results indicate phosphorus limitation at the time the sample was collected (05/02/73). The lake data indicate phosphorus limitation in August as well but probable nitrogen limitation in October.

C. Nutrient Controllability:

1. Point sources--No known municipal or industrial point sources impacted Lake Maxinkuckee during the sampling year. Lakeshore septic tanks were estimated to have contributed 3.5% of the

* See Appendix A.

total phosphorus load but a shoreline survey would be necessary to determine the significance of those sources.

The relatively small septic tank load is in agreement with an earlier evaluation of the impact of septic tanks on the lake prior to Indiana's phosphate detergent ban (Hamelink, 1971). However, these sources are potentially dangerous considering the number of people that could inhabit the existing shoreline dwellings. Hamelink (op. cit.) estimated that about 20% of the dwellings were occupied by full-time residents. Although the threat posed by expected growth was considered minimal by Hamelink, the associated activities (i e., boating, fishing, fertilizing of lawns on the lakeshore, etc.) would be expected to greatly increase the phosphorus loading to the lake.

The present phosphorus loading of 0.15 $g/m^2/yr$ is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading but is more than his oligotrophic loading; i.e., a mesotrophic loading (see page 12). However, all phosphorus inputs to the lake should be minimized to the greatest practicable degree since only a 30% increase in the existing loading would result in a eutrophic loading.

2. Non-point sources--The three gaged tributaries accounted for about 56% of the total phosphorus load reaching the lake during the sampling year. Unnamed Creek B-1 contributed 26.8%; Curtiss Ditch, 20.8%; and Wilson Ditch contributed 8.7% of the total load.

The ungaged immediate drainage area was estimated to have contributed 29.0%. The phosphorus load from this source may even be more significant because of the use of fertilizers on lakeshore lawns (Hamelink, op. cit.).

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 7.54 kilometers^2.
2. Mean depth: 7.3 meters.
3. Maximum depth: 26.8 meters.
4. Volume: 55.042 x 10^6 m^3.
5. Mean hydraulic retention time: 6.7 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Wilson Ditch	5.7	0.05
Unnamed Creek B-1	6.5	0.06
Curtiss Ditch	6.2	0.06
Minor tributaries & immediate drainage -	9.6	0.09
Totals	28.0	0.26

2. Outlet -

Wilson Ditch	35.5**	0.26**

C. Precipitation***:

1. Year of sampling: 104.3 centimeters.
2. Mean annual: 92.6 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Maxinkuckee was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 12.2 meters at station 1 and 12.8 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE MAXINKUCKEE
STORET CODE 1843

PARAMETER	1ST SAMPLING (5/ 2/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/13/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	13.9 - 14.0	13.9	13.9	15.0 - 24.7	22.4	23.3	19.5 - 20.1	19.8	19.8
DISS OXY (MG/L)	9.5 - 9.7	9.6	9.7	0.0 - 9.0	5.9	7.9	7.6 - 8.2	7.9	7.9
CNDCTVY (MCROMO)	400. - 400.	400.	400.	326. - 360.	348.	354.	322. - 327.	324.	324.
PH (STAND UNITS)	8.3 - 8.3	8.3	8.3	7.5 - 8.5	8.2	8.4	8.3 - 8.5	8.4	8.4
TOT ALK (MG/L)	154. - 157.	156.	156.	140. - 166.	145.	141.	132. - 136.	134.	135.
TOT P (MG/L)	0.020 - 0.033	0.024	0.022	0.012 - 0.018	0.014	0.014	0.017 - 0.038	0.025	0.023
ORTHO P (MG/L)	0.002 - 0.003	0.002	0.002	0.003 - 0.004	0.004	0.004	0.008 - 0.014	0.010	0.009
NO2+NO3 (MG/L)	0.210 - 0.230	0.220	0.220	0.050 - 0.080	0.064	0.060	0.030 - 0.050	0.040	0.040
AMMONIA (MG/L)	0.070 - 0.080	0.074	0.070	0.060 - 0.470	0.133	0.060	0.050 - 0.100	0.072	0.070
KJEL N (MG/L)	0.480 - 0.700	0.537	0.550	0.380 - 0.700	0.443	0.400	0.880 - 1.000	0.980	0.980
INORG N (MG/L)	0.280 - 0.310	0.294	0.290	0.110 - 0.530	0.197	0.120	0.090 - 0.140	0.112	0.110
TOTAL N (MG/L)	0.620 - 0.920	0.757	0.770	0.350 - 0.760	0.587	0.480	0.830 - 1.050	0.940	0.940
CHLRPYL A (UG/L)	4.7 - 5.3	5.0	5.0	5.7 - 5.8	5.7	5.7	5.5 - 5.9	5.7	5.7
SECCHI (METERS)	2.7 - 3.4	3.0	3.0	2.1 - 2.3	2.2	2.2	2.1 - 2.1	2.1	2.1

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/02/73	1. *Fragilaria sp.*	510
	2. *Cyclotella sp.*	243
	3. Green filaments	146
	4. Flagellates	73
	5. *Melosira sp.*	49
	Other genera	217
	Total	1,238
08/03/73	1. Flagellates	340
	2. *Melosira sp.*	120
	3. *Stephanodiscus sp.*	120
	4. *Gomphosphaeria sp.*	100
	5. *Synedra sp.*	80
	Other genera	295
	Total	1,055
10/13/73	1. *Lyngbya sp.*	3,471
	2. *Fragilaria sp.*	131
	3. *Gomphosphaeria sp.*	109
	4. Flagellates	109
	5. *Microcystis sp.*	87
	Other genera	132
	Total	4,039

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
05/02/73	1	5.3
	2	4.7
08/03/73	1	5.8
	2	5.7
10/13/73	1	5.5
	2	5.9

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.259	0.1
0.050 P	0.060	0.259	6.3
0.050 P + 1.0 N	0.060	1.259	12.7
1.0 N	0.010	1.259	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Maxinkuckee was low at the time the sample was collected (05/02/73). There was a significant increase in yield when orthophosphorus was increased, but there was no change in yield when only nitrogen was added. These results indicate phosphorus limitation.

The lake data indicate phosphorus limitation in August as well (tne mean inorganic nitrogen/orthophosphorus ratio was 49/1). However, the data indicate probable nitrogen limitation in October (the mean N/P ratio was 11/1).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads at stations A-2, B-1, and C-1, in $kg/km^2/year$, and multiplying the means by the ZZ area in km^2.

Note that the estimated phosphorus load from septic tanks was reduced by 50% to adjust for the phosphate detergent ban in effect in Indiana since January, 1972.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Wilson Ditch	100	8.7
Unnamed Creek B-1	310	26.8
Curtiss Ditch	240	20.8
b. Minor tributaries & immediate drainage (non-point load) -	335	29.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	40	3.5
e. Known industrial - None	-	-
f. Direct precipitation** -	130	11.2
Total	1,155	100.0

2. Outputs -

Lake outlet - Wilson Ditch 195

3. Net annual P accumulation - 960 kg.

* Estimate based on 260 shoreline dwellings (20% full-time residences); see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Wilson Ditch	6,010	14.6
Unnamed Creek B-1	9,415	22.8
Curtiss Ditch	5,005	12.1
b. Minor tributaries & immediate drainage (non-point load) -	10,590	25.4
c. Known municipal STP's - None	-	-
d. Septic tanks* -	3,105	5.3
e. Known industrial - None	-	-
f. Direct precipitation** -	8,140	19.8
Total	42,265	100.0

2. Outputs -

Lake outlet - Wilson Ditch 8,650

3. Net annual N accumulation - 33,615 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Wilson Ditch	18	1,054
Unnamed Creek B-1	48	1,448
Curtiss Ditch	39	807

* Estimate based on 260 shoreline dwellings (20% full-time residences); see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.15	0.13	5.6	4.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Maxinkuckee:

"Dangerous" (eutrophic loading)	0.20
"Permissible" (oligotrophic loading)	0.10

V. LITERATURE REVIEWED

Hamelink, Jerry L., 1971. Limnology of Lake Maxinkuckee. MS, Dept. of Forestry & Cons., Purdue U., West Lafayette.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.056	1.660	466.667	19.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	384.500	5.030	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MOWSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	43 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	274
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	481
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATAHACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1843 LAKE MAXINKUCKEE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 35.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1843A1	35.5	0.419	0.507	0.728	0.677	0.436	0.334	0.198	0.065	0.065	0.068	0.173	0.323	0.332
1843A2	5.7	0.062	0.079	0.119	0.110	0.068	0.054	0.031	0.008	0.009	0.009	0.028	0.054	0.053
1843B1	6.5	0.071	0.091	0.136	0.125	0.079	0.062	0.037	0.010	0.010	0.010	0.031	0.062	0.060
1843C1	6.2	0.068	0.088	0.130	0.119	0.076	0.059	0.034	0.009	0.010	0.010	0.031	0.059	0.058
1843Z2	9.6	0.108	0.136	0.198	0.184	0.116	0.091	0.054	0.015	0.016	0.016	0.045	0.091	0.089

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 35.5
SUM OF SUB-DRAINAGE AREAS = 28.0
TOTAL FLOW IN = 3.12
TOTAL FLOW OUT = 3.99

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1843A1	6	73	0.651	10	0.821				
	7	73	0.284	17	0.099				
	8	73	0.198	20	0.127				
	9	73	0.062	10	0.054				
	10	73	0.062	17	0.045				
	11	73	0.127	16	0.074				
	12	73	0.311	27	0.425				
	1	74	0.708	22	0.566				
	2	74	0.850	12	0.821	26	0.850		
	3	74	1.048	14	1.303	25	0.934		
	4	74	0.595	16	0.708				
	5	74	0.481	14	0.510				
1843A2	6	73	0.105	10	0.136				
	7	73	0.034	17	0.017				
	8	73	0.031	20	0.020				
	9	73	0.010	10	0.008				
	10	73	0.010	17	0.008				
	11	73	0.020	16	0.011				
	12	73	0.048	27	0.068				
	1	74	0.116	22	0.096				
	2	74	0.139	12	0.133	26	0.136		
	3	74	0.170	14	0.215	25	0.153		
	4	74	0.099	16	0.113				
	5	74	0.076	14	0.088				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1843 LAKE MAXINKUCKEE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
184381	6	73	0.119	10	0.153				
	7	73	0.040	17	0.017				
	8	73	0.034	20	0.023				
	9	73	0.011	10	0.008				
	10	73	0.011	17	0.008				
	11	73	0.024	16	0.014				
	12	73	0.057	27	0.076				
	1	74	0.133	22	0.105				
	2	74	0.159	12	0.153	26	0.153		
	3	74	0.193	14	0.241	25	0.170		
	4	74	0.113	16	0.125				
	5	74	0.088	14	0.099				
1843C1	6	73	0.116	10	0.147				
	7	73	0.037	17	0.017				
	8	73	0.037	20	0.023				
	9	73	0.011	10	0.011				
	10	73	0.011	17	0.008				
	11	73	0.023	16	0.014				
	12	73	0.057	27	0.074				
	1	74	0.130	22	0.105				
	2	74	0.147	12	0.147	26	0.147		
	3	74	0.187	14	0.238	25	0.170		
	4	74	0.110	16	0.125				
	5	74	0.088	14	0.096				
1843ZZ	6	73	0.176	10	0.227				
	7	73	0.059	17	0.025				
	8	73	0.051	20	0.034				
	9	73	0.016	10	0.012				
	10	73	0.016	17	0.012				
	11	73	0.034	16	0.021				
	12	73	0.085	27	0.113				
	1	74	0.198	22	0.156				
	2	74	0.235	12	0.227	26	0.227		
	3	74	0.283	14	0.368	25	0.252		
	4	74	0.167	16	0.184				
	5	74	0.130	14	0.147				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

184301
41 12 51.0 086 24 42.0 3
LAKE MAXINKUCKEE
18099 INDIANA

051792

11EPALES 2111202
0032 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	14 30	0000	14.0		108	400	8.30	155	0.080	0.600	0.220	0.002
	14 30	0004	14.0	9.5		400	8.30	154	0.070	0.500	0.220	0.003
	14 30	0015	14.0	9.7		400	8.30	157	0.080	0.400	0.230	0.003
	14 30	0028	14.0	9.5		400	8.30	156	0.070	0.400	0.220	0.002
73/08/03	15 00	0000	24.0		90	356	8.50	140	0.060	0.500	0.060	0.004
	15 00	0005	23.3	8.2		354	8.40	141	0.060	0.400	0.060	0.004
	15 00	0015	23.3	7.9		354	8.30	141	0.060	0.300	0.060	0.004
	15 00	0030	22.5	4.5		338	7.80	146	0.140	0.400	0.080	0.004
	15 00	0040	15.0	0.0		326	7.50	166	0.470	0.700	0.060	0.004
73/10/13	10 30	0000	20.1		84	325	8.50	132	0.050	0.800	0.040	0.008
	10 30	0004	20.1	8.2		327	8.50	134	0.050	1.000	0.050	0.008

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	14 30	0000	0.033	5.3
	14 30	0004	0.022	
	14 30	0015	0.030	
	14 30	0028	0.020	
73/08/03	15 00	0000	0.014	5.8
	15 00	0005	0.013	
	15 00	0015	0.018	
	15 00	0030	0.012	
	15 00	0040	0.015	
73/10/13	10 30	0000	0.017	5.5
	10 30	0004	0.022	

STORET RETRIEVAL DATE 76/03/30

184302
41 11 48.0 086 24 06.0 3
LAKE MAXINKUCKEE
18099 INDIANA

051792

11EPALES 2111202
0046 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	15	15 0000	13.9		132	400	8.30	156	0.080	0.700	0.220	0.003
	15	15 0015	13.9	9.7		400	8.30	156	0.070	0.500	0.210	0.002
	15	15 0028	13.9	9.7		400	8.30	157	0.070	0.600	0.220	0.002
	15	15 0042	13.9	9.7		400	8.30	157	0.070	0.600	0.220	0.002
73/08/03	15	30 0000	24.7		84	360	8.50	140	0.080	0.500	0.080	0.003
	15	30 0005	23.9	9.0		351	8.50	140	0.060	0.300	0.050	0.003
73/10/13	11	35 0000	19.5			322	8.30	135	0.100	1.000	0.040	0.014
	11	35 0004	19.5	7.6		323	8.30	136	0.090	0.800	0.030	0.011

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	15	15 0000	0.022	4.7
	15	15 0015	0.020	
	15	15 0028	0.023	
	15	15 0042	0.023	
73/08/03	15	30 0000	0.013	5.7
	15	30 0005	0.014	
73/10/13	11	35 0000	0.024	5.9
	11	35 0004	0.038	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/30

1843A1
41 12 17.0 086 25 12.0 4
WILSON DITCH
18 7.5 CULVER
O/LAKE MAXINKUCKEE 051792
RD BRDG AT S EDGE OF CULVER
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 00		0.138	0.670	0.028	0.009	0.025
73/07/17	19 40		0.026	0.580	0.015	0.010	0.010
73/08/20	15 28		0.011	0.580	0.012	0.019	0.020
73/09/10	12 14			0.560	0.033	0.010	0.015
73/10/17	15 00		0.016	0.800	0.054	0.005K	0.050
73/11/16	10 15		0.046	0.550	0.064	0.005K	0.025
73/12/27	10 55		0.052	0.900	0.050	0.005	0.010
74/01/22	14 50		0.112	0.200	0.032	0.005	0.005
74/02/12	10 00		0.260	0.600	0.030	0.005K	0.010
74/02/26	10 55		0.232	0.600	0.050	0.005	0.025
74/03/14	14 40		0.288	1.100	0.045	0.005	0.005
74/03/25	10 15		0.264	0.700	0.050	0.005	0.020
74/04/16	11 35		0.312	0.700	0.040	0.005K	0.010
74/05/14	14 40		0.224	0.600	0.040	0.010	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1843A2
41 13 16.0 086 23 46.0 4
WILSON DITCH
18 7.5 CULVER
I/LAKE MAXINKUCKEE 051792
ST RD 117 BRDG NEAR CULVE MILITARY ACAD
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 45		1.560	1.320	0.084	0.042	0.097
73/07/17	18 10		0.610	0.810	0.210	0.021	0.100
73/08/20	16 02		0.400	0.600	0.120	0.037	0.075
73/09/10	12 40		0.340	0.810	0.100	0.009	0.050
73/10/17	15 30		0.378	0.600	0.088	0.007	0.025
73/11/16	09 55		0.180	0.300	0.048	0.005K	0.030
73/12/27	10 25		8.200	1.300	0.112	0.064	0.130
74/01/22	14 20		6.500	1.500	0.128	0.035	0.085
74/02/12	10 30		3.900	1.300	0.110	0.015	0.032
74/02/26	11 25		3.700	1.500	0.285	0.015	0.055
74/03/14	15 10		2.520	1.100	0.075	0.020	0.030
74/03/25	10 40		2.100	1.200	0.130	0.010	0.030
74/04/16	11 30		1.600	1.000	0.055	0.010	0.030
74/05/14	15 05		1.840	1.200	0.065	0.025	0.060

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

184381
41 10 46.0 086 23 12.0 4
UNNAMED CREEK
18 7.5 CULVER
T/LAKE MAXINKUCKEE 051792
W 208 RD BRDG 4 MI SSE OF CULVER
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 15		3.200	1.700	0.210	0.063	0.120
73/07/17	17 50		1.580	1.320	0.068	0.066	0.085
73/08/20	15 42		1.340	0.630	0.040	0.520	0.660
73/09/10	12 20		1.420	0.400	0.062	0.036	0.060
73/10/17	15 10		1.200	1.400	0.096	0.032	0.140
73/11/16	10 10		0.960	1.500	0.150	0.044	0.210
73/12/27	10 45			1.900	0.148	0.076	0.180
74/01/22	14 40		7.500	1.800	0.180	0.140	0.240
74/02/12	10 10		5.700	1.900	0.175	0.040	0.115
74/02/26	11 05		5.700	2.100	0.210	0.035	0.150
74/03/14	14 50		4.100	1.700	0.090	0.050	0.097
74/03/25	10 25		3.800	1.650	0.175	0.020	0.065
74/04/16	11 45		3.200	1.900	0.105	0.030	0.050
74/05/14	14 50		2.500	1.300	0.085	0.045	0.110

STORET RETRIEVAL DATE 76/03/30

1843C1
41 12 14.0 086 23 18.0 4
CURTISS DITCH
18 7.5 CULVER
T/LAKE MAXINKUCKEE 051792
ST RD 117 BRDG NEAR E SIDE OF LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 25		0.252	3.100	0.120	0.048	0.420
73/07/17	18 00		0.084	0.750	0.026	0.018	0.055
73/08/20	15 58		0.357	2.900	0.200	0.066	0.540
73/09/10	12 30		0.176	0.560	0.050	0.030	0.075
73/10/17	15 20		0.198	0.950	0.073	0.018	0.055
73/11/16	10 00		0.132	0.750	0.035	0.020	0.080
73/12/27	10 35		4.800	1.500	0.216	0.144	0.240
74/01/22	14 30		4.400	0.800	0.084	0.075	0.105
74/02/12	10 20		2.600	0.900	0.090	0.030	0.050
74/02/26	11 15		2.520	1.500	0.165	0.030	0.070
74/03/14	15 00		1.600	0.700	0.030	0.015	0.020
74/03/25	10 30		1.200	0.600	0.040	0.010	0.020
74/04/16	11 35		0.720	1.300	0.070	0.015	0.030
74/05/14	15 00		0.570	0.900	0.040	0.025	0.060